/04Activity: Bucket Brigade

Candles and matches, contained in jars, make tidy fires. Wildland fires are anything but tidy. In this activity, teams of students try to start a fire using branches, leaves, and needles (fig. 1) - some of which have been partially burned. Then they try to explain what happens in terms of the fire triangle.

This is an outdoor activity. Select a place far from dry grass, bark chips, and other fuels. Make sure a hose is available and ready to use. Because the students will be using matches, you may want to ask some parents or other volunteers to help. Also, please note that you have to gather the fuels yourself for this experiment.

Figure 1 – Elementary student and volunteer firefighter evaluating the flammability of their fuel recipe.

Materials Needed

Supplied in fire education kit:

- 5 aluminum pans
- Wooden matches

You must supply:

- Water hose or water bottles
- Non-plastic trash can
- Fire extinguisher
- Fuels (green leaves and/or needles, small dead & dry branches, charred fuels from a fire place or campfire, large dead & dry branches, dry leaves or needles.

Here are the Fuel Recipes

Recipe # 1	green leaves and/or needles (attached to twigs)
Recipe #2	dead & dry branches, small diameter (0.5 cm), mixed with green leaves and/or needles
Recipe #3	small dead & dry branches, plus dry leaves and/or needles
Recipe #4	large dead & dry branches, mixed with small-diameter branches
Recipe #5	charred fuels from campfire or fireplace mixed with small branches

Preparation

Collect green foliage (you can leave small branches attached). Store the green leaves and/or needles in a plastic bag in the refrigerator until the day you use them. They can be stored for a week or two. Collect small diameter (<0.5 cm) dead & dry branches, large dead & dry branches, dry needles and/or leaves, and charred fuels from a campfire or fireplace.

Procedure

1. Explain: Five teams of students will try to start small fires in the aluminum tins. It may not be easy! Each team will assemble a pan with a certain mixture of fuels, specified on their Fuel Recipe. They must carefully plan a strategy to get as much of

their fuel as possible to burn within 15 minutes. Remind students that fires will not burn unless all three parts of the fire triangle are present. (fuel, oxygen, heat source)

2. Divide the students into five teams. Give each team a Fuel Recipe card from the Fire Education kit, plus an aluminum pan.
3. Give seven matches to each team. Seven is all they get. This is their heat source.
4. Have the students follow the team's recipe to place the right combination of fuels in their pan. The fuels have to fit inside the pan, not be hanging over the edges and spilling out.
5. Go over the following rules with the students:
    - Each team must work together.
    - The whole team is responsible for safety. If any student is injured, the experiment stops.
    - All fires must be built within the pan on the designated surface (pavement or gravel, away from cars, buildings, and dry vegetation).
    - Each team must stick to its recipe. No other fuels may be added.
    - Each team gets only 7 matches; no more may be used.
    - Each team MUST use a 2-minute group planning session before lighting any matches; they can arrange the fuels in the pan in any way they wish.
6. Go outside to the location where students will build their fires.
7. Tell students to begin planning.
8. After two minutes, tell students that they may begin lighting their fires.
9. After 15 minutes, stop the activity.
10. As a class, take a "tour" of the work sites. Discuss how successful each fire was and why it burned well or didn't. **Here are some discussion points:**

Green fuels have much more moisture than dead fuels, unless it's been raining lately. Moisture affects the Fire Triangle in two ways: First, you have to evaporate the moisture before you can heat the fuel to the ignition point (450 to 6000 Fahrenheit, 260 to 3200 Celsius). If things are really wet, the water also keeps oxygen from the fuel.

Green fuels usually contain about as much water (by weight) as the plant tissue itself! The moisture of dead, dry vegetation depends on its environment but can be as low as 3 percent of the material's weight. So green fuels may be difficult to start on fire.

Once green fuels start to burn, however, they may produce more heat than dead ones. Green fuels contain more stored energy than dead ones because they contain oils and other "volatile" compounds that deteriorate after the fuels die.

Large particles, like the big branches, are much harder to ignite than small particles. That's because the small pieces have much more surface area exposed to oxygen and to the heat of the match than the large pieces do. (Scientists call this the "surface-area-to-volume ratio; as this number increases, fires bum more readily.)

Plant matter is a mixture of burnable "stuff' (carbon compounds that combine readily with oxygen in the presence of heat) and unburnable minerals such as silicon, which glass is made of. Charred wood from an old campfire has had much of its carbon burned off, especially from the surface of the fuel, so it is harder to ignite than unburned wood.

11 . Ask the students what factors other than fuel condition came into play as they built their fires. What strategies did they use to try to get the fires to burn?

Evaluation

Using the five kinds of fuels provided in this activity, write a recipe for a fire that would burn really well. Write a paragraph that uses the Fire Triangle to explain why you think your recipe is a good one.

Closure

If time permits, let students assemble their own combination of fuels to make a really good fire. Give them seven matches again and see how well the new "fuel recipes" burn. Ask students to clean up materials and put equipment away. All burnt material should be disposed of in non-plastic trash can.

Extensions

1. The discussion points in #10 above mention that the moisture content of fuels is very important in determining how well they burn. Design an experiment to measure the moisture content of various fuels and express it as a percent of dry weight. If equipment is available (an oven for drying and a balance for weighing), do the experiment and report results to the class.
2. The discussion points also mention that surface-area-to-volume ratio affects how well fuels burn. Design and carry out an experiment to determine whether high or low surface-area-to-volume ratios favor better burning. You will need to measure some large twigs and small twigs, estimate their total surface area and volume of each, calculate their surface-area-to-volume ratios, and attempt to burn them.